Buletin Profesi Insinyur 5(2) (2022) 101–106
http://dx.doi.org/10.20527/bpi.v5i2.172

ISSN 2654-5926

Over-Dimension and Overloading Truck Accident Model with Structural Equation Modeling Partial Least Square

Ismatud Dianah Amir[1], Meriana Wahyu Nugroho[1], Tri Rijanto[2], Sumarsono[3]

[1] Civil Engineering, University of Hasyim Asy'ari Tebuireng Jombang

[2] Electrical Engineering, State University of Surabaya

[3] Industrial Engineering, University of Hasyim Asy'ari Tebuireng Jombang

✉ ismatuddianahamir99@gmail.com

Road accidents are an unavoidable problem, especially accidents caused by Over-dimension and Overloading trucks. This study involved environmental factors, driver factors, vehicle factors, and road factors which had previously been analyzed using the multinomial logistic regression method with questionnaire data of 194 respondents and resulted in 6 indicators including road surface conditions, traffic flow volume, accident history, vehicle load, vehicle dimension, and speed limit signs. The purpose of this study was to find out relationship between latent variables using the Structural Equation Modeling Partial Least Square (SEM PLS) method to obtain a model of the factors causing Over-dimension and Overloading truck accidents. The model results obtained indicate that weather conditions, road surface conditions, lighting condition, certified training, driver's physical condition, vehicle type, vehicle dimension, vehicle load, road geometry, accident location, traffic facilities, as well as vehicle dimension, and speed limit signs were the variables that had the greatest influence. The model obtained was good and fit (fit model) based on the R2 and Chi-Square values of 65.7% and 76.3%, respectively.

Keywords: Over-dimension and Overloading Trucks; Road Accidents; SEM PLS; Factors Causing Accidents

Submitted: 13 November 2022
Revised: 2 Desember 2022
Accepted: 28 Desember 2022
Published online: 29 Desember 2022

Introduction

Traffic safety remains a top priority in national transportation (Wang & Qin, 2014). Accidents caused by trucks cause serious safety problems (Naderi et al., 2021). Factors that contribute to truck accidents include road geometry, traffic conditions, environmental conditions, driver characteristics, and vehicle characteristics (Dong et al., 2015). Trucks that exceeded the dimension limit had an influence of 82.4% on the increase in accidents, while the load had an influence of 44.7% (Nugroho & Amir, 2021). Over-dimension and overloading of trucks had another impact, namely the impact on transportation costs, human, social, and economic. Road surface conditions, traffic flow volume, accident history, and speed limit signs were the determining factors for accidents (Meriana Wahyu Nugroho Ismatud Dianah Amir, 2021). The truck's excessive load damaged the road structure (Simanjuntak et al., 2014). This phenomenon often occurs in countries that have a lot of interest in freight transportation. On the other hand, over-dimension and overloading of trucks for the company made operational costs reduced and efficient. However, this caused the potential for serious accidents to occur in road safety (Wen et al., 2022). Over-dimension and overloading truck accidents occurred due to disruption of the visibility of other drivers (Shams et al., 2021). The fatality rate of death was more dominant caused by over-dimension and overloading of trucks (Chang & Chien, 2013).

The driver's contribution also had an influence that needs to be identified, including age, gender, driving experience, duration of driving on each route, as well as the status of the license owned (Y. Wang et al., 2019). Based on traffic accident data from the Jombang Resort Police in 2016–2020, traffic accidents caused by driver factors reached 94%. Fatigue and lack of sleep were two driving factors that influenced the occurrence of accidents (Naderi et al., 2018). The driver's behavior in driving is to obey traffic rules and also know driving techniques so that it has a safe and secure impact for themselves and others (Arianto & Feriana, 2021). Drivers who are relatively young and inexperienced tend to be more aggressive when driving, so the chance of an accident is greater (Budi Dwi Hartanto, 2020). The occurrence of truck accidents can occur on arterial roads and toll roads (Tjahjono, 2016). Accidents caused by over-dimension and overloading trucks are more common on freeways (Cho et al., 2017).

The dimension and load of trucks that exceed the limit (Wang et al., 2019; Haq et al., 2020) were one of the factors that had a very large contribution to the occurrence of accidents due to the very large dimension and the load transported exceeding the limit. This could interfere with the visibility of other drivers, and truck

How to cite this article:
Amir, I.D., Nugroho, M.W., Rijanto, T., Sumarsono (2022) Over-Dimension And Overloading Truck Accident Model With Structural Equation Modeling Partial Least Square. *Buletin Profesi Insinyur* 5(2) 101-106

This is an open access article under the CC BY-NC-SA license

 ISSN 2654-5926

drivers would also have difficulty controlling the truck. When a truck is involved in an accident, it causes a greater degree of severity compared to other vehicles (Yuan et al., 2019). The condition of the driver being sleepy and tired (Shams et al., 2021) was also an important variable in the driver's factor that influenced the occurrence of accidents because this physical condition caused the driver to pay less attention when driving (Naderi et al., 2018). In addition to physical conditions, there was a driver's demographic factor that influenced the increasing incidence of road accidents, namely the age of the driver (Shams et al., 2021).

During bad weather, wet road surface conditions are common; this type of road condition has contributed to an increase in the number of accidents. In addition to road surface conditions, road conditions with too sharp bend conditions also influenced increasing accidents (Yuan et al., 2019) .

Through SEM PLS (Structural Equation Modeling Partial Least Square) analysis in three stages at once, including validity, reliability, and modeling among latent variables, this analysis technique can estimate relationships among variables that have multiple relationships (Santoso, 2011) (Figure 1). where the relationships among variables were described in the form of a structural model. The application of SEM has been widely carried out in research in the field of transportation (Lee et al., 2008).

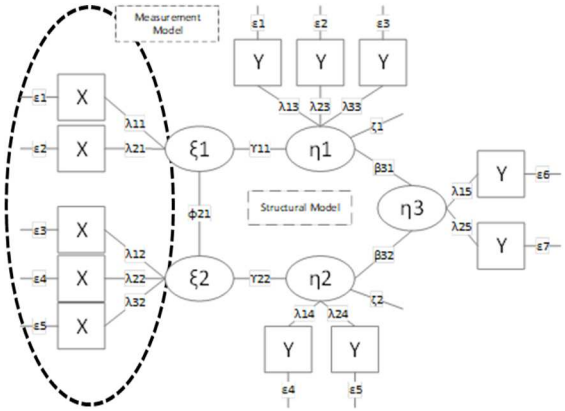

Figure 1. Example of a structural equation modeling (Santoso, 2011)

Through several stages of testing, starting with discriminant validity with the reliability of indicator variables measuring factor variables and the outer model with the convergent test, and to find out the significance of the relationship among the factors, the inner model test was carried out with the t-test. The process carried out was in the context of analyzing SEM (Structural Equation Modeling) data. The first stage was in the outer analysis of the convergent test model (Leguina, 2015) by checking the loading factor value and the average variance extracted (AVE) value. The discriminant test was obtained from the comparison of the AVE root values and the largest correlation value among factors using the Fornell-Lacker criterion. In the preparation of the variable reliability assessment model obtained from reliability testing (Leguina, 2015). Next, determine the significance value of the influence coefficient among factors, the coefficient of determination (R^2) as an assessment of how much variation can be explained by the influence of endogenous factors on exogenous factors, and Chi-Square for the prediction of endogenous factors in the inner model (Leguina, 2015).

Methods

The previous research stages used the Multinomial Logistics Regression Method (Ali Kemal Celik, 2014) with 194 respondents. From the results of the first stage of the study, the influencing factors included road surface conditions, traffic flow volume, accident history, vehicle load, vehicle size/dimensions, and speed limit signs. In this second research stage, continued analysis of modeling using the structural equation modeling (SEM) method (Sumarsono & Muflihah, 2021) was conducted through the stages of testing the validity and reliability of the data as well as modeling among variables, with a research flow like the flowchart below shown in Figure 2.

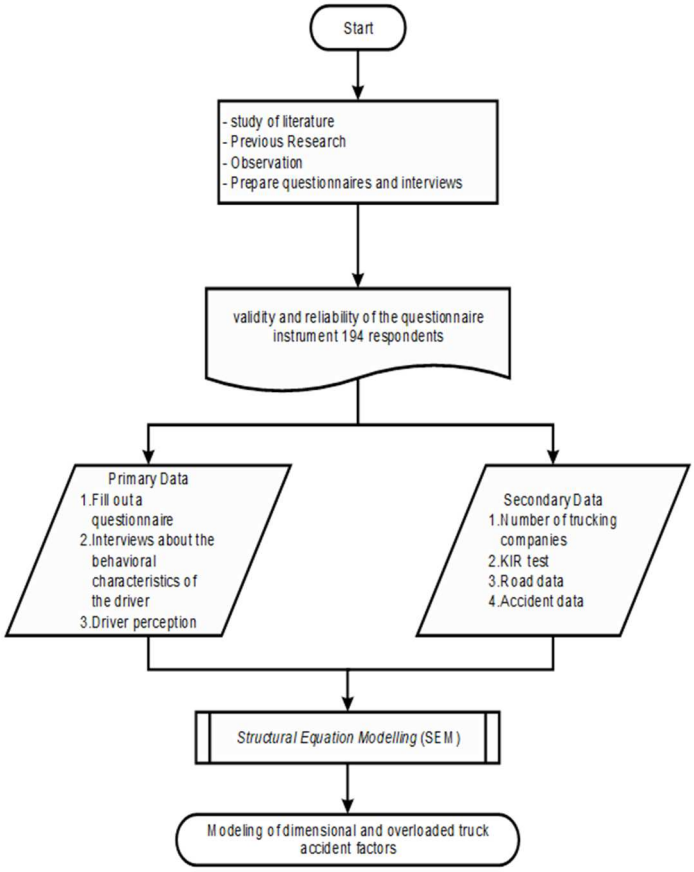

Figure 2. Research flowchart

The initial stage of analysis that needed to be done was to form an initial structural model, as shown in Figure 3.

 ISSN 2654-5926

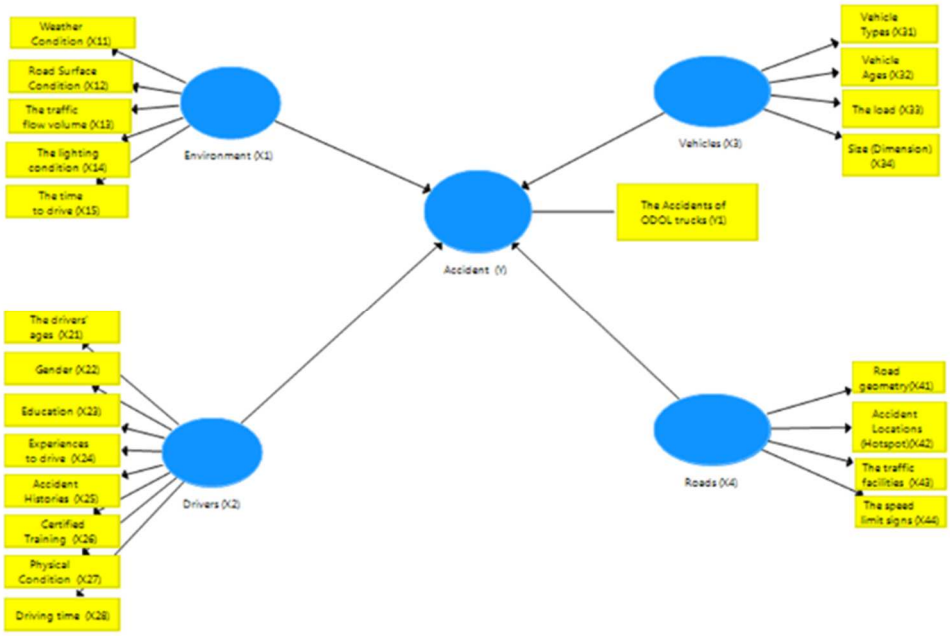

Figure 3. Initial structural modeling

The formation of the initial model with 4 variable factors on the occurrence of over-dimension and overloading truck accidents includes environmental factors, which have 5 indicators, driver factors, which have 8 indicators, vehicle factors, and road factors, each of which has 4 variable indicators. After the initial structural model is formed, check the loading factor value to find out the number of valid variable indicators. Furthermore, the validity of each variable can be determined by knowing the average variance extracted (AVE) value. After the validity test, the reliability test was continued by looking at the composite reliability and Cronbach's alpha values. followed by checking the inner model by looking at the significance value of the influence of each factor on the accident, then looking at the percentage of conformity of the model with the value of determination (R^2) and Chi-Square. After the results of the model conformity met the requirements, a model of the factors that contributed to over-dimension and overloading truck accidents would be obtained.

Results and Discussions

A Outer Model Test Result

1) Convergent Validity Test

Convergent validity test results on environmental factors, drivers, vehicles, and road variables. There were 9 out of 22 invalid indicators, it could be seen from the factor loading value which had a low value, which had a low value of less than 0.5. While the other 13 indicators were declared convergently valid. Followed by the process of eliminating nine invalid indicator variables so that 13 valid indicators were obtained as the new outer model. The variables in the model are said to be valid if the average variance extracted (AVE) value is greater than 0.5. This showed that each variable had good discriminant validity (Table 1).

Table 1. Convergent validity test result: significant outer model

Factor (Construct)	Indicator Variables	*Outer Model*			
		Loading factor	**Information**	**AVE**	**Information**
Environment (X_1)	Weather Conditions (X_{11})	0.820	valid	0.677	Convergent
	Road Surface Condition (X_{12})	0.866	valid		
	The Lighting Condition (X_{14})	0.781			
Driver (X_2)	Certified Training (X_{26})	0.884	valid	0.760	Convergent
	Physical Condition (X_{27})	0.859	valid		
Vehicle (X_3)	Vehicle Type (X_{31})	0.896	valid	0.794	Convergent
	Vehicle Load (X_{33})	0.830	valid		Convergent
	Vehicle Size/ Dimension (X_{34})	0.943	valid		
Road (X_4)	Road Geometry (X_{41})	0.774			
	Accident Location/Hotspot (X_{42})	0.883	valid	0.706	Convergent
	Traffic Facilities (X_{43})	0.796	valid		
	Speed Limit Sign (X_{44})	0.901	valid		
Accident (Y)	ODOL Truck Accident (Y_1)	1.000	valid	1.000	Convergent

 ISSN 2654-5926

2) Evaluation of Factor Consistency Test (Reliability)

Table 2 showed the results of the factor consistency test. There were 5 factors in the model with good reliability based on each composite reliability value on the factor variable with a value of more than 0.7, including the environment, driver, vehicle, and road.

Table 2. Result of factor consistency test: Composite reliability and Cronbach's Alpha

Factor	Composite Reliability	Cronbach's Alpha	Information
Environment(X1)	0.863	0.762	Reliable
Driver (X2)	0.864	0.685	Reliable
Vehicle (X3)	0.920	0.869	Reliable
Road (X4)	0.905	0.860	Reliable
Accident (Y)	1.000	1.000	Reliable

B Inner Model Test Result

1) Testing the influence among factors based on the significance of the coefficients.

The results of testing the coefficient of influence among factors are in Table 3. The t-statistic value of all relationships among factors exceeded the t-table value of 1.96, so it could be ascertained that exogenous factors had a significant influence on endogenous factors.

2) Evaluation of the coefficient of determination (R^2) and Chi-Square test.

The R-square value was 0.657, indicating the large contribution of the variation of the four exogenous variables to explaining the endogenous factors of 65.8% and being classified as having a good coefficient of determination (Table 4). And based on value by value predicted relevance (chi-square), 0.783 showed that there was conformity between the model formed and the actual data because it exceeded the alpha value of 0.05. As a result of the Chi-square test results, it was possible to conclude that the model was fit (model fit).

Table 3. The results of testing the influence value among factors

Relationship of Exogenous to Endogenous Factors	Influence Coefficient	t- Statistic	Information
Environment (X1) against accidents (Y)	0.318	5.361	Significant
Driver (X2) against accident (Y)	0.307	5.271	Significant
Vehicle (X3) against accidents (Y)	0.278	4.323	Significant
Road (X4) against accidents (Y)	0.135	2.317	Significant

Table 4. Result of R Square and Chi-square

Estimation Model	
Chi-Square	0.783
R Square	0.657

3) SEM-PLS model results: over-dimension and overloading truck accidents

The model fit of the overdimensioning and overloading truck accidents factor is shown in Figure 4. The modeling obtained that environmental factors had a direct and significant influence on the occurrence of over-dimension and overloading truck accidents of 0.318 with indicators of weather conditions, road surface conditions, and lighting conditions. The driver factor had an influence of 0.307 with indicators of certified training and physical condition, while the vehicle factor had an influence of 0.278 with indicators of vehicle type, vehicle dimension, and vehicle load. Dimension was the indicator that had the greatest influence. The road factor had an influence of 0.135 with indicators of road geometry, accident location, traffic facilities, and speed limit signs.

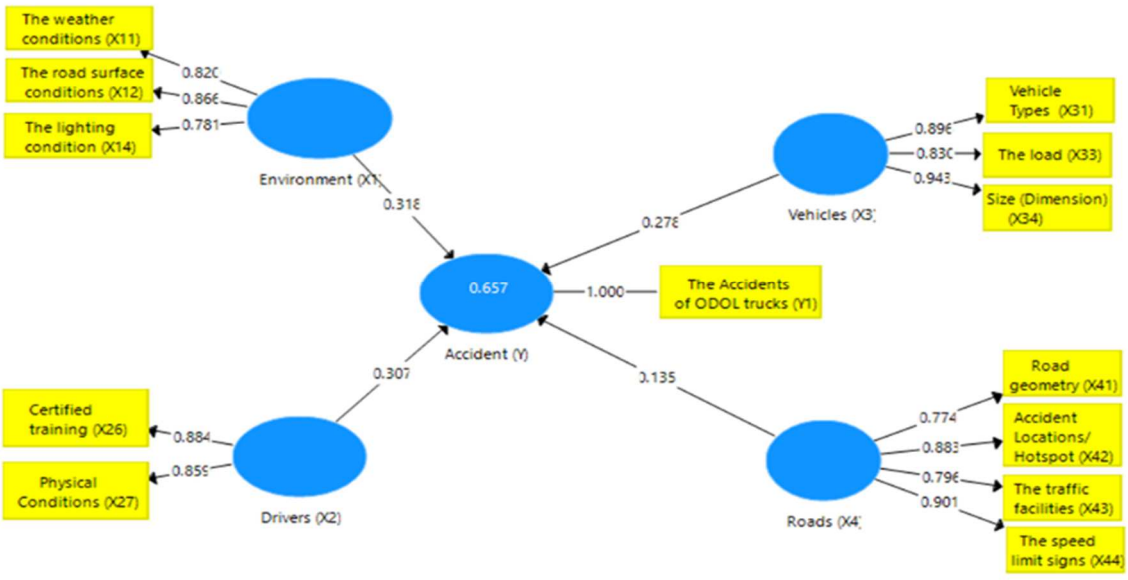

Figure 4. Model fit of over-dimension and overloading truck accidents factor: loading factor value, and coefficient of influence

The greatest influence was caused by environmental factors, but the driving factor was also a major contributing factor because it only had a difference of 0.006, as well as the vehicle factor, which only had a difference of 0.009 with the driving factor.

Conclusions

The results of the value of the relationship among all variables had a positive linear value, indicating the influence of increasing the occurrence of over-dimension and overloading truck accidents. The order of greatest influence is the indicator variables of vehicle dimension, speed limit signs, road surface conditions, vehicle type, certified training, weather conditions, accident locations, physical conditions, traffic facilities, and loads. The model obtained was good and fit (fit model) based on the R^2 and Chi-Square values of 65.7% and 76.3%, respectively.

References

Ali Kemal Celik, E. O. (2014). A Multinomial Logit Analysis of Risk Factors Influencing Road Traffic Injury Severities in the Erzurum and Kars Provinces of Turkey. *Accident Analysis and Prevention*, *72*, 66–77.

Arianto M, E. & Feriana, S., (2021). Pengetahuan Keselamatan Berkendara, Masa Kerja Dan Peran Manajemen Dengan Perilaku Keselamatan Berkendara Pada Pengemudi Truk Bermuatan Semen Di PT Energi Sukses Abadi Cilacap. *Jurnal Kesehatan Masyarakat*, *8*(1), 14–20. https://ojs.uniska-bjm.ac.id/index.php/ANN/article/view/3924

Budi Dwi Hartanto. (2020). Analisis Perilaku Pengemudi Truk serta Kontribusinya pada Kecelakaan. *Journal of Chemical Information and Modeling*, *53*(9), 1689–1699. http://ppid.dephub.go.id/files/datalitbang/JURNAL_DARAT_2015.pdf

Chang, L. Y., & Chien, J. T. (2013). Analysis of driver injury severity in truck-involved accidents using a non-parametric classification tree model. *Safety Science*, *51*(1), 17–22. https://doi.org/10.1016/j.ssci.2012.06.017

Cho, S.-H., Kim, D.-K., & Kho, S.-Y. (2017). Latent Factors of Severity in Truck-Involved and Non-Truck-Involved Crashes on Freeways. *International Journal of Transport and Vehicle Engineering*, *11*(7), 920–927.

Dong, C., Richards, S. H., Huang, B., & Jiang, X. (2015). Identifying the factors contributing to the severity of truck-involved crashes. *International Journal of Injury Control and Safety Promotion*, *22*(2), 116–126. https://doi.org/10.1080/17457300.2013.844713

Haq, M. T., Zlatkovic, M., & Ksaibati, K. (2020). Investigating Occupant Injury Severity of Truck-involved Crashes Based on Vehicle Types on A Mountainous Freeway. *Accident Analysis and Prevention*, *144*(105654).

Lee, J. Y., Chung, J. H., & Son, B. (2008). Analysis of traffic accident size for Korean highway using structural equation models. *Accident Analysis and Prevention*, *40*(6), 1955–1963. https://doi.org/10.1016/j.aap.2008.08.006

Leguina, A. (2015). A primer on partial least squares structural equation modeling (PLS-SEM). *International Journal of Research & Method in Education*, *38*(2), 220–221. https://doi.org/10.1080/1743727x.2015.1005806

Nugroho, M.W. & Amir, I.D. (2021). *Initial Study of Truck Accident Overdimension and Overloading on Arterial Road Using A Multinomial Logistic Regression Method*. Research report. University of Hasyim Asy'ari Tebuireng Jombang

Naderi, H., Nassiri, H., & Sahebi, S. (2018). Assessing the relationship between heavy vehicle driver sleep problems and confirmed driver behavior measurement tools in Iran. *Transportation Research Part F: Traffic Psychology and Behaviour*, *59*, 57–66. https://doi.org/10.1016/j.trf.2018.08.007

Naderi, H., Nassiri, H., & Zahedieh, F. (2021). Predicting the Collisions of Heavy Vehicle Drivers in Iran by Investigating the Effective Human Factors. *Journal of Advanced Transportation*, *2021*(1). https://doi.org/10.1155/2021/5532998

Santoso, S. (2011). *Structural Equation Modeling (SEM) Konsep dan Aplikasi dengan AMOS 18*. Penerbit PT Elex Media Komputindo.

Shams, Z., Naderi, H., & Nassiri, H. (2021). Assessing the effect of inattention-related error and anger in driving on road accidents among Iranian heavy vehicle drivers. *IATSS Research*, *45*(2), 210–217. https://doi.org/10.1016/j.iatssr.2020.09.005

Simanjuntak, G. I., Pramusetyo, A., Riyanto, B., & Supriyono. (2014). Analisis Pengaruh Muatan Lebih (Overloading) Terhadap Kinerja Jalan dan Umur Rencana Perkerasan Lentur (Studi Kasus Ruas Jalan Raya Pringsurat, Ambarawa-Magelang). *Jurnal Karya Teknik Sipil. Universitas Diponegoro. Semarang*, *3*(3), 539 – 551. https://ejournal3.undip.ac.id/index.php/jkts/index

Sumarsono, S., & Muflihah, N. (2021). Penentuan Strategi Rantai Pasok Umkm Yang Kompetitif Berdasarkan Logistical-Crossfunctional Drivers: Studi Kasus Umkm Di Kabupaten Jombang – Jawa Timur. *J@ti Undip : Jurnal Teknik Industri*, *16*(1), 42–55. https://doi.org/10.14710/jati.16.1.42-55

Tjahjono, T. (2016). Upaya Peningkatan Keselamatan Pada Jalan Nasional Indonesia. *Jurnal Transportasi*, *16*(2), 143–150. http://journal.unpar.ac.id/index.php/journaltransportasi/article/view/2363

Wang, K., & Qin, X. (2014). Use of Structural Equation Modeling to Measure Severity of Single-Vehicle Crashes. *Transportation Research Record: Journal of the Transportation Research Board*, *2432*(1), 17–25. https://doi.org/10.3141/2432-03

Wang, Y., Luo, Y., & Chen, F. (2019). Interpreting Risk Factors for Truck Crash Severity on Mountainous Freeways in Jiangxi and Shaanxi, China. *European Transport Research Review*, 11–26.

Wen, H., Du, Y., Chen, Z., & Zhao, S. (2022). *Analysis of Factors Contributing to the Injury Severity of Overloaded-Truck-Related Crashes on Mountainous Highways in China*. International Journal of Environmental Research and Public Health 19(7): 4244 DOI: 10.3390/ijerph19074244

ISSN 2654-5926

Yuan, Y., Yang, M., Gan, Z., Wu, J., Xu, C., & Lei, D. (2019). Analysis of the Risk Factors Affecting the Size of Fatal Accidents Involving Trucks Based on the Structural Equation Model. *Transportation Research Record*, *2673*(8), 112–124. https://doi.org/10.1177/0361198119841042